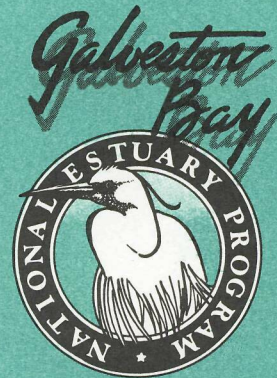


# Characterization of Selected Public Health Issues in Galveston Bay



Galveston Bay  
National Estuary Program

GBNEP-21  
August 1992



---

# Characterization of Selected Public Health Issues in Galveston Bay

---

---

# Characterization of Selected Public Health Issues in Galveston Bay

---

**Paul Jensen, Ph.D., P.E.  
Principal Investigator**

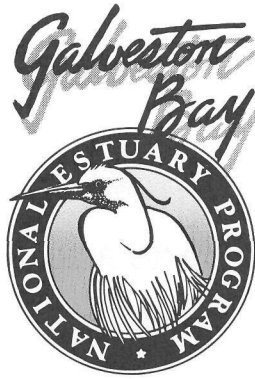
**Prepared By  
Paul Jensen, Ph.D., P.E. and  
Yu-Chun Su, Ph.D.**

**Espey, Huston & Associates, Inc.  
Engineering & Environmental Consultants  
P.O. Box 519  
Austin, Texas 78767**

**The Galveston Bay National Estuary Program**

**Publication GBNEP-21  
August 1992**

*This project has been funded in part by the United States Environmental Protection Agency under assistance agreement # CE-006550-01 to the Texas Water Commission. The contents of this document do not necessarily represent the views of the United States Environmental Protection Agency or the Texas Water Commission, nor do the contents of this document necessarily constitute the views or policy of the Galveston Bay National Estuary Program Management Conference or its members. The information presented is intended to provide background information, including the professional opinion of the authors, for the Management Conference deliberations in drafting of official policy in the Comprehensive Conservation and Management Plan (CCMP). The mention of trade names or commercial products does not in any way constitute an endorsement or recommendation for use.*



### **Policy Committee**

The Honorable Rodney Ellis, Chair  
*Texas Senate*

Mr. Buck J. Wynne, III, Vice-Chair  
*Regional Administrator, EPA Region 6*

Mr. John Hall  
*Chair,*  
*Texas Water Commission*

Mr. John Wilson Kelsey  
*Vice-Chair,*  
*Texas Parks and Wildlife Commission*

Ms. Linda Shead  
*Executive Director*  
*Galveston Bay Foundation*

Mr. Charles W. Jenness  
*Chair,*  
*Texas Water Development Board*

Ms. Eileen Crowley  
*Former President*  
*Greater Houston Partnership*  
*Chamber of Commerce Division*

The Honorable Jon Lindsay  
*County Judge, Harris County*

### **Local Governments Advisory Committee**

The Honorable Ray Holbrook, Chair

### **Management Committee**

Mr. Myron O. Knudson, Chair

Ms. Barbara Britton, Vice-Chair

### **Scientific/Technical Advisory Committee**

Dr. Robert McFarlane, Chair

Ms. Teresa Battenfield, Vice-Chair

### **Citizen's Advisory Steering Committee**

Ms. Sharron Stewart, Chair

Ms. Glenda Callaway, Vice-Chair

### **Galveston Bay Public Forum**

Dr. Don Bass, Chair

### **Program Director**

Dr. Frank S. Shipley

## TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
List of Figures	x
List of Tables	xii
Executive Summary	1
1.0 <u>INTRODUCTION</u>	3
2.0 <u>INDICATOR ORGANISMS AND WATER QUALITY CRITERIA</u>	7
2.1 INTRODUCTION OF INDICATOR BACTERIA	7
2.1.1 <u>Total and Fecal Coliform</u>	8
2.1.2 <u>Escherichia Coli</u>	9
2.1.3 <u>Fecal Streptococcus</u>	9
2.1.4 <u>Enterococcus</u>	10
2.1.5 <u>Discussion on Indicator Organisms</u>	10
2.2 DISCUSSION OF FEDERAL AND STATE WATER QUALITY CRITERIA	11
2.2.1 <u>General Texas Water Quality Criteria for Bacteria</u>	11
2.2.2 <u>Texas Water Quality Criteria for Designated Segments</u>	11
2.2.3 <u>EPA Water Quality Criteria for Bacteria</u>	12
2.2.4 <u>Discussion of EPA 1986 Criteria</u>	13
2.3 HISTORICAL WATER QUALITY CRITERIA FOR SHELLFISH GROWING WATERS	14
3.0 <u>REVIEW OF ACTIVITIES ASSOCIATED WITH SHELLFISH BED CLOSURES</u>	17
3.1 TDH REGULATORY PROCEDURES (NSSP)	17
3.2 HISTORICAL MAPS SHOWING SHELLFISH CLOSURES	20
3.3 TRENDS OF BAY AREAS IN TERMS OF "POLLUTED" CONDITIONALLY APPROVED, AND APPROVED	22

## TABLE OF CONTENTS (Cont'd)

<u>Section</u>	<u>Page</u>
3.4	23
DIFFERENCES IN CLOSURE AREAS WITH CHANGE FROM TOTAL TO FECAL COLIFORM AS REGULATORY CRITERIA	
3.5	24
CURRENT CLASSIFICATIONS OF BAY AREAS	
3.6	26
TDH MONITORING AND MANAGEMENT PRACTICES	
3.7	26
TDH MPN & TWC MEMBRANE FILTER APPROACHES & LIMITATIONS	
3.7.1	28
<u>TDH Quality Assurance Procedures</u>	
3.7.2	28
<u>TWC Quality Assurance Procedures</u>	
3.8	29
COMPARISON OF TDH PROGRAM WITH OTHER COASTAL STATES	
3.9	31
CONCLUSIONS	
4.0	33
<u>INDICATOR BACTERIA INPUTS TO GALVESTON BAY</u>	
4.1	33
PERMITTED WASTEWATER DISCHARGES	
4.2	34
COLLECTION SYSTEM LEAKS, OVERFLOWS AND EXCURSIONS	
4.3	43
SEPTIC SYSTEM FAILURES	
4.4	45
RUNOFF INPUTS OF FC BACTERIA	
4.5	49
DISCUSSION AND ANALYSIS	
5.0	53
<u>ANALYSES OF COLIFORM DATA</u>	
5.1	53
DATA DESCRIPTION	
5.1.1	53
<u>Segmentation of Galveston Bay System</u>	
5.1.2	53
<u>Sources and Types of Coliform Data</u>	
5.2	57
STATISTICS ON COLIFORM DATA FOR GALVESTON BAY SYSTEM	
5.3	61
RELATIONSHIP BETWEEN TC and FC	
5.4	66
TEMPORAL TRENDS	

## TABLE OF CONTENTS (Concluded)

<u>Section</u>		<u>Page</u>
5.5	DISCUSSION AND CONCLUSIONS	76
6.0	<u>OTHER PUBLIC HEALTH ISSUES</u>	87
6.1	THE <u>VIBRIO</u> ORGANISM, ITS REQUIREMENTS, RELATION TO ANTHROPOGENIC SOURCES AND CHARACTERISTICS	87
6.1.1	<u>Influence of Environmental Conditions on Survival of Pathogenic Vibrios</u>	87
6.1.2	<u>Mechanisms of Infection by Vibrios</u>	89
6.2	<u>VIBRIO</u> OCCURRENCE, INCIDENTS OF ILLNESS & FATALITIES, AND MECHANISMS OF INFECTION	91
6.3	RELATIONSHIP BETWEEN <u>VIBRIO</u> OCCURRENCE & CORRESPONDING FECAL COLIFORM RECORDS	95
6.4	INVESTIGATION OF OTHER PUBLIC HEALTH CONCERNS	100
6.5	CONCLUSIONS	101
7.0	<u>REFERENCES</u>	103
APPENDIX A - HISTORICAL CLASSIFICATION MAPS FOR SHELLFISH GROWING WATERS IN GALVESTON BAY SYSTEM		
APPENDIX B - FECAL COLIFORM MPN AND MEMBRANE FILTER TESTING PROCEDURES		



## LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
3-1	The 1991 Classification of Shellfish Growing Waters in Galveston Bay System	25
3-2	Sampling Stations for Galveston Bay Area	27
5-1	Quadrilaterals for Galveston Bay Areas	56
5-2	Long-term Mean Fecal Coliform Levels in Galveston Bay	60
5-3	Percentages of Long-term Mean Fecal Coliform Levels Exceeding 14 Colonies/100 mL Criterion in Galveston Bay	62
5-4	Percentages of Long-term Mean Fecal Coliform Levels Exceeding 200 Colonies/100 mL Criterion in Galveston Bay	63
5-5	Relationship Between Long-term Mean Total and Fecal Coliform Levels in Galveston Bay	67
5-6	Quadrilaterals Selected for Trend Analysis	68
5-7a	Fecal Coliform Data for Quadrilateral 2439d (Lower Galveston Bay Near East Bay)	69
5-7b	Pseudo Fecal Coliform Data for Quadrilateral 2439d (Lower Galveston Bay Near East Bay)	70
5-8a	Fecal Coliform Data for Quadrilateral 2421b (Upper Galveston Bay Near La Porte)	72
5-8b	Pseudo Fecal Coliform Data for Quadrilateral 2421b (Upper Galveston Bay Near La Porte)	73
5-9a	Fecal Coliform Data for Quadrilateral 2421c (Upper Galveston Bay)	74
5-9b	Pseudo Fecal Coliform Data for Quadrilateral 2421c (Upper Galveston Bay)	75

## LIST OF FIGURES (Concluded)

<u>Figure</u>		<u>Page</u>
5-10a	Fecal Coliform Data for Quadrilateral 1005i (Houston Ship Channel Near Morgan's Point)	77
5-10b	Pseudo Fecal Coliform Data for Quadrilateral 1005i (Houston Ship Channel Near Morgan's Point)	78
5-11a	Fecal Coliform Data for Quadrilateral 2421d (Upper Galveston Bay Near Seabrook)	79
5-11b	Pseudo Fecal Coliform Data for Quadrilateral 2421d (Upper Galveston Bay Near Seabrook)	80
5-12a	Fecal Coliform Data for Quadrilateral 2422a (Trinity Bay)	81
5-12b	Pseudo Fecal Coliform Data for Quadrilateral 2422a (Trinity Bay)	82
5-13a	Fecal Coliform Data for Quadrilateral 2424d (East Part of West Bay)	83
5-13b	Pseudo Fecal Coliform Data for Quadrilateral 2424d (East Part of West Bay)	84

## LIST OF TABLES

<u>Table</u>	<u>Page</u>
3-1 Shellfish Classification Maps Issued by TDH	21
4-1 Tabulation of Houston Wastewater Disinfection and Bypass Performance	35
4-2 City of Houston Sewer Leak Monitoring Data	38
4-3 Average Year Total Non-point Source (NPS) Loads Per Area by Watershed	48
4-4 Comparison of Measured FC Levels and FC Concentrations Calculated From Runoff	51
5-1 Quadrilaterals in Galveston Bay System	54
5-2 Analysis of Fecal Coliform Data	58
5-3 Relationship Between TC and FC Data	64
6-1 Pathogenic Vibrio Species Associated with Various Human Infections (After West, 1989)	90
6-2 Vibrio Infections in Counties Around Galveston Bay	92
6-3 Vibrio Infections Associated with Activities in Galveston Bay	93
6-4 Statistics of Vibrio Infections in Galveston Bay	94
6-5 Vibrio Infections in Harris and Dallas Counties	96
6-6 Relationship Between Reported Vibrio Infections and Levels of Fecal Coliform	98
6-7 Long-term Mean Fecal Coliform Levels for Segments in Galveston Bay	99

## EXECUTIVE SUMMARY

The purpose of this project is to characterize public health issues associated with bay use activities such as shellfish consumption and contact and non-contact recreation. The major objectives of this characterization study are:

1. Review and summarize activities associated with shellfish bed closures,
2. Identify and characterize sources of bacterial contamination,
3. Review and characterize areas of Galveston Bay which have exceeded water quality standards for contact and non-contact recreation, and
4. Assess the incidence of known pathogenic organisms such as Vibrio Vulnificus.

The characterization includes consideration of indicator organisms and known pathogenic organisms and covers all identified water quality segments of Galveston Bay.

The report is an analysis of existing data obtained from agencies involved with public health protection and regulation--the Texas Department of Health (TDH) and the Texas Water Commission (TWC) as well as information provided by Galveston and Harris counties, the City of Houston, and numerous other sources. There are six major sections in this report. The first is an introduction which provides an overview of the project. The second section briefly introduces and compares indicator organisms used by various agencies, and their relation with pathogens. The EPA and Texas water quality criteria for indicator organisms are reviewed as well as a brief historical review of the National Shellfish Sanitation Program (NSSP). A more detailed analysis of the TDH implementation of the NSSP is the subject of Section 3.0. Section 4.0 focuses on sources of bacterial input to Galveston Bay. The objective is to analyze and quantify to the extent practical the contribution of indicator organisms to Galveston Bay from a range of sources. Section 5.0 is an analysis of available indicator organism data, including spatial and temporal patterns. Section 6.0 describes an investigation of the possible relationship between indicator organism levels and known pathogenic microorganisms in Galveston Bay. Among the pathogens, Vibrios are of primary concern because of their medical significance and their ability to be transmitted through various contact and noncontact recreational activities as well as the consumption of seafood.

The major conclusions, described in more detail in each section, include:

1. While many changes have taken place over the years in shellfish harvesting regulation, there have been no major changes in the areas closed to shellfish



harvesting. Analyses on the coliform data show that many areas classified as "polluted" or closed to shellfish harvesting do not have high long-term mean indicator levels. The classification is generally a result of either a small portion of the data exceeding higher values, generally after rains, or a judgement made about the potential for upland facilities to introduce pathogens.

2. All open bay areas of Galveston Bay conform to current Texas water quality criteria for contact recreation. The only areas whose overall long-term median FC levels exceed the 200 col/dL contact recreation criteria are inland areas: Houston Ship Channel, Houston area bayous (Greens, Sims, Hunting, Brays, Buffalo, Clear Creek), Dickinson Bayou and Bastrop Bayou Tidal.
3. From admittedly noisy coliform bacteria data, which are available back to roughly 1950, no change could be detected over time that could be associated with watershed development activities.
4. As an indicator of the possible presence of human wastes and thus diseases associated with human waste, the total and later FC bacteria tests have a long and quite successful history. However, over the last several decades, it is becoming increasingly obvious that the tests have numerous limitations. These include frequent "false positives" - essentially naturally occurring bacteria which "pass" the test, failure to correlate with pathogens directly measured in some studies, and failure to provide an alert for naturally occurring pathogenic microorganisms.
5. Among the sources of indicator bacteria loadings to the Galveston Bay, wet weather runoff contributes the most significant amount. However, due to the die-off rate of bacteria, high concentrations in the bay tend to be localized and of short duration.
6. No significant correlation between indicator bacteria levels and incidents of Vibrio diseases could be found in the data.

## 1.0 INTRODUCTION

The purpose of this project is to characterize public health issues associated with bay use activities such as shellfish consumption and contact and non-contact recreation. The major objectives of this characterization study are:

1. Review and summarize activities associated with shellfish bed closures,
2. Identify and characterize sources of bacterial contamination,
3. Review and characterize areas of Galveston Bay which have exceeded water quality standards for contact and non-contact recreation, and
4. Assess the incidence of known pathogenic organisms such as Vibrio Vulnificus.

The characterization includes consideration of indicator organisms and known pathogenic organisms and covers all identified water quality segments of Galveston Bay. Existing data that were employed in this work included:

### Texas Department of Health (TDH)

- Indicator bacteria data computer files and paper listings,
- Shellfish classification maps showing each change in Shellfish harvesting area boundaries, and
- Files of Vibrio and other pathogen identifications;

### Texas Water Commission (TWC)

- Machine readable copy of Statewide Monitoring Network (SMN) data (coliforms, temperature, salinity) for selected stations in the bay, along with paper copy of above for data checking, and
- Paper listing of files for all permitted point sources discharging to the listed bay segments.

There are six major sections in this report. The first is this introduction which provides an overview of the project. The second section briefly introduces and compares indicator organisms used by various agencies, and their relation with pathogens. In addition, the Environmental Protection Agency (EPA) and Texas water quality criteria for indicator organisms are reviewed. A brief historical review of the National Shellfish Sanitation Program (NSSP) concerning the use of indicator organisms for the classification of shellfish growing waters is also included in Section 2.

Section 3 of this report summarizes the TDH implementation of the requirements of the NSSP for segments in Galveston Bay. The objective is to review current and historical regulations and shellfish classification boundaries. The review included:

1. TDH regulatory procedures (NSSP),
2. historical maps showing prohibited shellfish growing areas,
3. trends of bay areas in terms of prohibited, conditionally approved, and approved growing areas,
4. differences in prohibited areas with change from total to fecal coliform as regulatory criteria,
5. current classifications of bay areas,
6. TDH monitoring and management practices,
7. a comparison of measurement techniques for coliform bacteria, and
8. comparison of the Texas program with those in other coastal states.

Section 4 focuses on sources of bacterial input to Galveston Bay. The objective is to analyze and quantify to the extent practical the contribution of indicator organisms to Galveston Bay from a range of sources. The sources considered include:

1. permitted wastewater discharges,
2. wastewater collection system leaks, overflows and excursions,
3. partially treated wastewaters from failed septic systems, and
4. runoff from watershed areas.

Section 5 documents results from analyzing both total and FC data from the TDH, TWC and predecessor agencies, including the Texas Water Quality Board (TWQB, the old Galveston Bay Project) for the Galveston Bay system. This section starts with a brief description of the sub-segmentation of the Galveston Bay segments into quadrilaterals. Statistical and regression analyses on the historical coliform data and comparisons are described with various indicator bacteria criteria. The relationship between total and FC was investigated based on long-term geometric means of the data. Finally, the collected coliform data are used to investigate possible temporal trends for several representative quadrilaterals in the open bay areas.

Section 6 describes an investigation of the possible relationship between indicator organism levels and known pathogenic microorganisms in Galveston Bay. Among the pathogens, Vibrios are of primary concern because of their medical significance and their ability to be transmitted through various contact and noncontact recreational activities as well as the consumption of seafood. The first part of this section is a description of Vibrio bacteria. Next, data obtained from TDH on the incidents of Vibrio infections in Texas were analyzed and reported. The relationship between these incidents and FC data was then

explored. Finally, brief investigation was performed to determine the existence of data about other known diseases which are associated with shellfish consumption.

There are two appendices attached to this report. The first is a copy of the available historical shellfish classification maps published by TDH. The second is a detailed description of indicator organism testing procedures. The shellfish classification maps in ARC-INFO format are provided to the GBNEP in diskettes under separate cover.